Using MEMS Devices to Build a "Fab on a Chip"

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In this talk we will discuss a novel approach to nanomanufacturing, the "Fab on a Chip" (FoC). As semiconductor technologies continue to shrink from the deep sub-micron regime into the nanometer regime, standard techniques to manufacture the devices are becoming more and more challenging. The conventional methods using photo resist, liftoff and optical/deep-UV/E-beam lithography have created the need for multi-billion dollar fabs, but they have no hope of ultimately scaling into the regime of single or few atom devices. However, it is clear that progress in device physics is advancing such that in the not too distant future, we will need and desire single atom devices despite the fact that we have no clear idea of how such circuits could be made using a scalable nanomanufacturing process.

In this talk we discuss the concept of building a Fab on a Chip, a technique of directly depositing circuits and structures with atomic beams using small numbers of atoms or even single atoms under the control of a MEMS writing device. We discuss our approach of re-creating on a single silicon chip, all of the elements one finds in a VLSI fab and then using that system to directly fabricate nanoscale devices. We believe our approach has the potential to allow one to build single or few atom devices in a scalable and manufacturable way with high volumes, low costs and high yield. In a very real sense, we are using macro-machines to build micro-machines and then using these micro-machines to mass produce nanostructures. We believe our approach advances manufacturing technology through the use of what is, in essence, a 3D printer at the atomic scale allowing us to assemble materials in a digitally programmable way. As we will show, our approach works as well for creating nano-mechanical devices as well as electronic ones.

The approach we are proposing here is to combine low temperature, quench condensed evaporation with MEMS programmable stencils, e.g. the ability to directly write structures and patterns while evaporating. Two recent advances that make our proposal feasible are the extraordinary developments in MEMS technologies so that aperture(s) can be moved with sub-nm precision and control while evaporating a film and the ability, using modern FIBs and TEMs, to create nm-sized holes in silicon wafers. Figures 1 and 2 show examples of two of our devices for use in our Fab on a Chip. Figure 1 shows a MEMS-based digital atom source. This is an array of MEMS plates that can be individually heated, creating a source of atoms with precise control from attograms to nanograms. Arrays with many different kinds of atoms can be built on a single chip, allowing for a programmable source of a wide range of atoms. Figure 2 shows our lithography tool. It is a MEMS writer plate with a nanoscale aperture. By moving the plate while depositing atoms, one can essentially "spray paint" atoms where one wishes them to be.

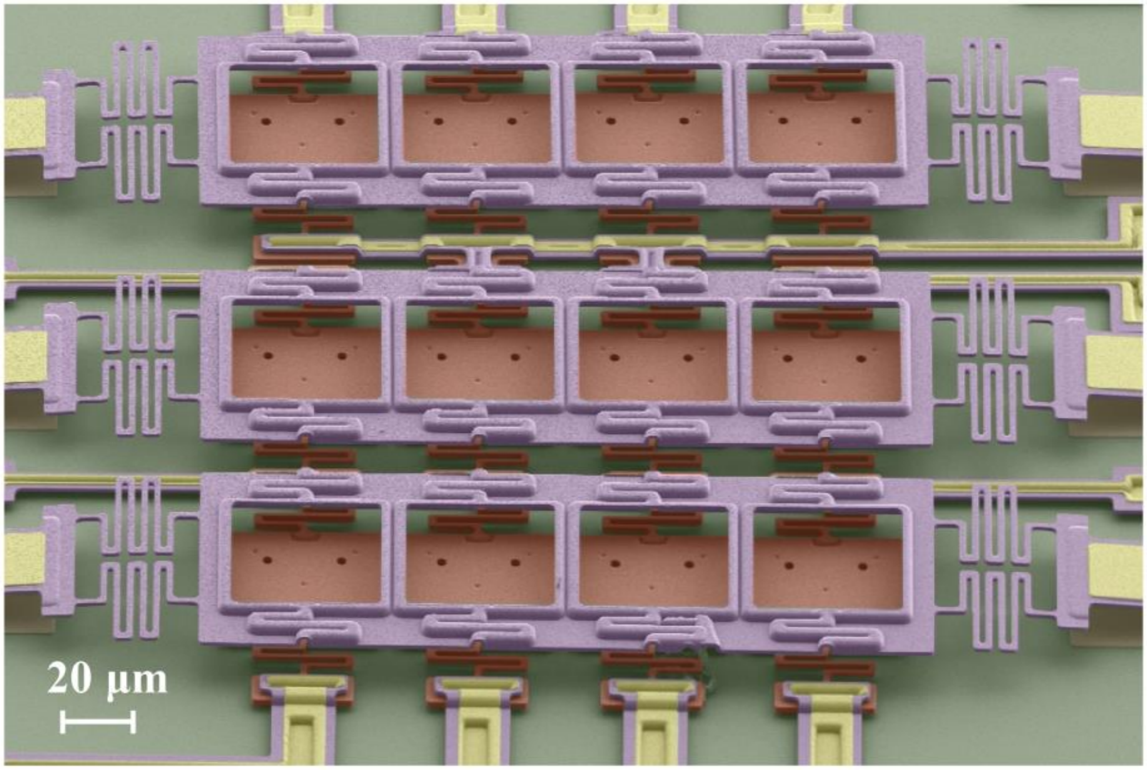

Figure 1: Shown is a MEMS programmable atom source for nanofabrication.

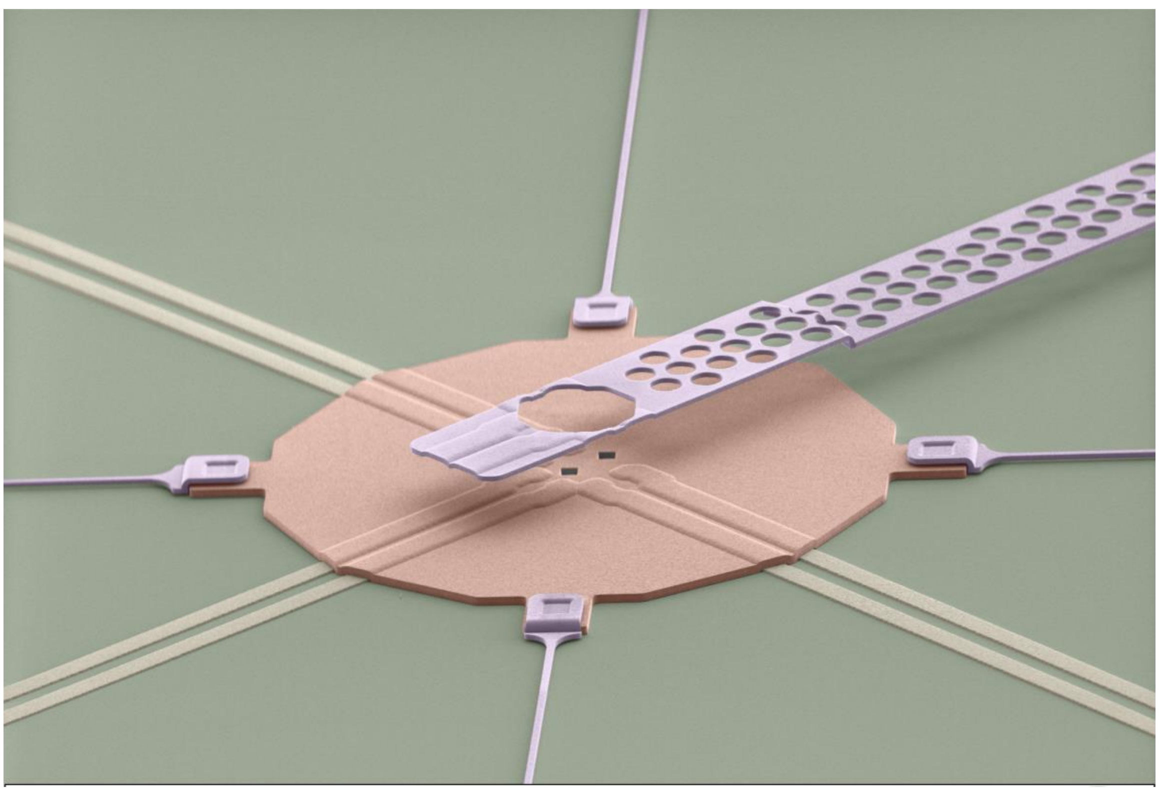

Figure 2: Shown is a MEMS writer plate for patterning atoms during deposition.